

# Special Materials for Weapons and Other Applications

Nuclear weapons include highly reactive metals—plutonium and uranium—as well as organic compounds that degrade over time from exposure to radiation, high temperatures, and accumulated gases. Thus, ensuring the performance of an aging stockpile is a major challenge, but far from the only one facing chemists and materials scientists at the Laboratory. They are frequently tasked to develop or evaluate the performance of novel materials to be used in very demanding applications.

## Modeling and Experiments to Understand Plutonium

One major success story of the Stockpile Stewardship Program is the significant improvement that researchers are making in understanding the extremely complex material properties of plutonium. As the plutonium in deployed weapons grows older, the effect of aging-related changes on weapon performance must be thoroughly understood. To this end, scientists at Livermore and Los Alamos are pursuing a comprehensive program of theoretical studies, computer simulations, shock-physics tests, and laboratory experiments. An important new research tool came on line in 2001, the Joint Actinide Shock Physics Experimental Research (JASPER) Facility at the Nevada Test Site. Livermore has taken the lead for NNSA in constructing JASPER and bringing it into operation.

JASPER’s two-stage gas gun accelerates projectiles to speeds of nearly 8 kilometers per second to produce an extremely high-pressure shock wave in a target. The facility is designed for the use of uranium and plutonium targets. Researchers will soon begin to collect valuable equation-of-state data to augment information gathered from high-static-pressure (diamond anvil) experiments conducted at Livermore and from subcritical tests. In 2001, Livermore also completed its last two of eight subcritical tests in the Oboe series and prepared for its next experiment, Piano. Conducted in an underground tunnel at the Nevada Test Site, these highly instrumented experiments provide data on the behavior of plutonium when it is strongly shocked

with explosives and how that behavior depends on the plutonium’s age. Test diagnostics include a laser-based system to obtain holographic images of plutonium ejecta from the shocked surface at the moment of explosion. The film images, when projected with a laser, allow experimenters to see in three dimensions a cloud of plutonium and analyze the size, shape, and velocity of the particles. Complementing the shocked-material experiments are a combination of computer simulations and laboratory experiments. They are providing new insights about the long-term effects of radiation on materials—for applications ranging from pressure vessels in nuclear reactors to radioactive waste containers to components of nuclear warheads.

1950s



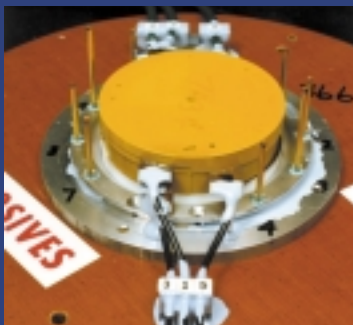
From its beginning, the Laboratory has pursued research on actinides, including uranium, plutonium, and heavier elements. The research has led to current efforts to understand the effect of aging on plutonium in weapons and the recent discovery—with Russian collaborators—of element 114, which is the heaviest element and comparatively long-lived.

1960s



The development of special materials for special applications has been the hallmark of many Livermore programs. For the Pluto “flying” nuclear reactor, a prototype of which was successfully tested in the 1960s, chemists and materials scientists were challenged to develop mass-producible ceramic fuel elements that would work in very stressful operating conditions.

1970s



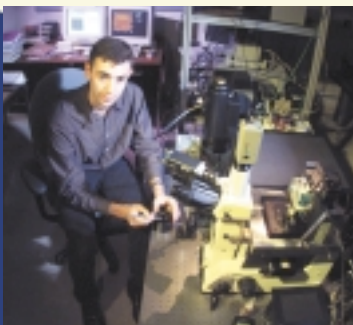
Livermore and Los Alamos developed insensitive high explosives to improve weapon safety. Researchers also began to explore the properties of fiber composites for a wide range of applications. Many projects focused on ensuring the compatibility of the many disparate materials that must coexist for decades inside nuclear weapons.

1980s



Extreme materials, such as ultralight aerogels used on the Mars Explorer, were developed for special applications. Powerful lasers and two-stage gas guns were used to study materials under extreme conditions, leading to the creation of metallic hydrogen in the 1990s and much better data to characterize deuterium at starlike conditions.

1990s



Experimental and computational capabilities are enabling Laboratory researchers to understand the behavior of materials from the atomic level to the bulk-properties level. Nano-engineered and computer-designed materials are providing ultrahigh strength, ultrahigh capacitance, and unique optical properties to meet demanding programmatic needs.